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Static Structural Analysis of Vented and Non Vented Disc Brake

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ABSTRACT
The current study essentially deals with the modeling and analyzing vented and non vented disc brake by CATIA and ANSYS. Finite element models of the brake-disc are shaped with CATIA and simulated using ANSYS which is based on the finite element method. This study Structural analysis is done so as to get the strength of the disc brake. Here we discuss disc brake which is used in many vehicles. The stresses and variations developed in vented and non-vented disc brakes are discussed using ANSYS software. Disc gets stressed when used in slowing down or stopping the vehicle. So that by using Ansys we can observe variations between stresses of vented and non-vented disc brake. Disc brakes are mostly used on front wheels in two-wheelers, hatchback cars and also widely used on both front and rear wheels of high end cars.

The main aim of this paper is to minimize the Total deformation, Directional deformation, Equivalent stress and strain with best suited Material Analysis is done on both Vented and non vented disc brake. The Geometry of the models is carried out in the CATIA V5 R20 Software and is designed in Mechanical Design. The analysis part is done by using ANSYS R14.5 Software.

KEYWORDS: *vented, Non vented, hatchback, Catia and Ansys*

1. INTRODUCTION
A vehicle requires a brake system to stop or adjust its speed with changing road and traffic conditions. The basic principle used in braking systems is to convert the kinetic energy of a vehicle into some other form of energy.

For example, in friction braking it is converted into heat, and in regenerative braking it is converted into electricity or compressed air etc. During a braking operation not all the kinetic energy is converted into the desired form, e.g. in friction braking some energy might be dissipated in the form of vibrations.

So to get optimum performance in demanding applications, ventilation is introduced in the brake discs which increases the cooling rate. Brake discs could be divided into two categories:
1. Ventilated disk brake
2. Non-Ventilated or Solid disk brake

2. PRINCIPLE OF BRAKING SYSTEM
A brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine. Break play a major role in moving automotive vehicles.

A disk brake consists of a cast iron disc bolted to the wheel hub and a stationary hosing called caliper the caliper is connected to some stationary part of the vehicle like the axle casing or stub axle as in two parts each part containing a piston. in between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the caliper for the fluid enter or leave each housing the passages are also connected to another one for bleeding. Each cylinder and piston.

When the brakes are applied, hydraulically actuated pistons move the friction pads into contact with the rotating disc, applying equal and opposite forces on the disc. Due to the friction between disc and pad surfaces the kinetic energy of the rotating wheel is converted into heat, by which vehicle is to stop after a certain distance. On releasing the brakes the brakes rubber-sealing ring acts as return spring and retract the pistons and the friction pads away from the disc.

3. DESIGN OF DISC BRAKE
Designing of vented and non vented disc brake rotor using the ISO standard dimensions of BMW car in CATIA V5.

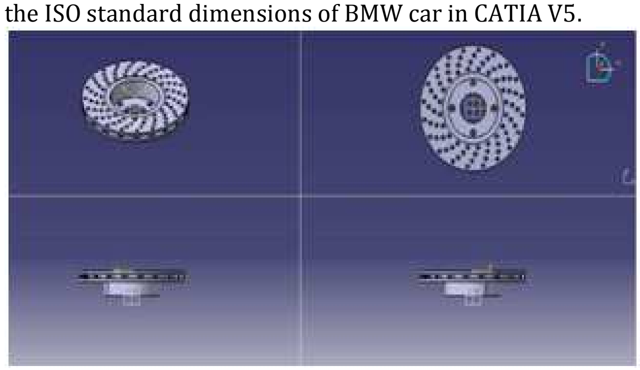


Fig 1: Three Dimensional Vented Disc brake

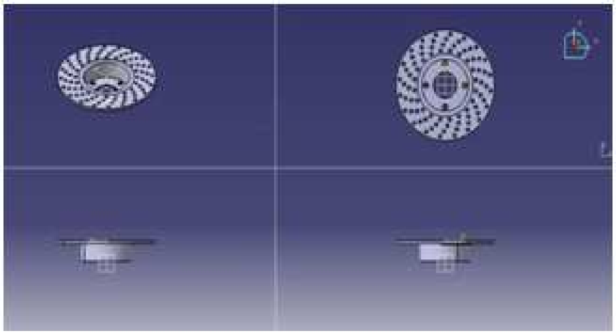


Fig 2: Three Dimensional Non Vented Disc brake

4. DESIGN CALCULATION BENDING TEST

The bending moment to be imparted in the test shall be in accordance with the following formula:

$$M = ((\mu * R) + d) * F * S$$

M = Bending moment in 'Nm'
μ = Friction Coefficient between the tire and the road surface(no units)
R = Radius of the tyre applicable to the wheel in 'm' d = Offset of the wheel in 'm'
F = Maximum load acting on the tire in 'N' S = Coefficient specified according to the standards.

Tyre specification Radial 315/60-R18

315 is the section width in millimeters 60 is the Aspect ratio in percentage

R is the construction type i.e., Radial 18 is the rim diameter in inches

Aspect ratio = section height / section width
Section height = Section width * Aspect ratio
= 315 * 0.60
= 189 mm
= 0.189 m
Rim radius = 144 mm
= 0.144 m
Tyre radius = Rim Radius + Section height
= 0.144 + 0.189= 0.333 m

According to the industrial standards:
μ = 0.7 R=0.333m
d = 37 mm = 0.037m F=1400lbs
= 1400 * 0.453
= 634.2 kg
= 634.2 * 9.81
= 6221.5 N
S = 1.5

Bending moment

M = ((μ*R) + d)* F * S
= ((0.7 * 0.333) + 0.037) * 6221.5 * 1.5
= 2520.65 Nm
= 252065Nmm

5. MATERIAL SELECTION

It plays an important role in product design and manufacturing. This is guided by the way the material behaves in the real-time conditions according to its use. The material response to the environmental stimulus is called property. Based on the application and usage of material, its properties become significant.

Properties	Gray Cast Iron	Titanium Alloy	Stainless Steel
Density	7.2e-006 kg mm^-3	4.62e-006 kg mm^-3	7.75e-006 kg mm^-3
Young's Modulus	1.1e+005 MPa	96000 MPa	1.93e+005 MPa
Poisson's Ratio	0.28	0.36	0.31
Coefficient of Thermal Expansion	1.1e-005 C^-1	9.4e-006 C^-1	1.7e-005 C^-1
Specific Heat	4.47e+005 mJ kg^-1 C^-1	5.22e+005 mJ kg^-1 C^-1	4.8e+005 mJ kg^-1 C^-1
Thermal Conductivity	5.2e-002 W mm^-1 C^-1	2.19e-002 W mm^-1 C^-1	1.51e-002 W mm^-1 C^-1
Resistivity	9.6e-005 ohm mm	1.7e-003 ohm mm	7.7e-004 ohm mm

STATIC STRUCTURAL ANALYSIS

Workbench allows you to copy systems in order to efficiently perform and compare multiple similar analyses.

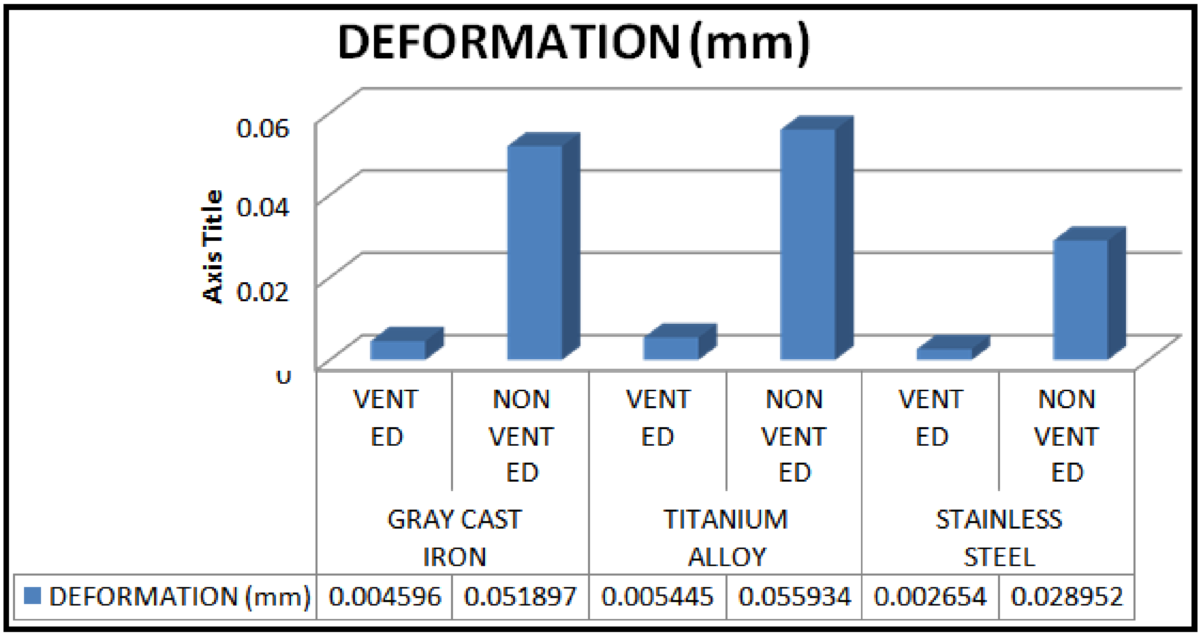
Static analysis is performed over a structure when the loads and boundary conditions remain stationary and do not change over Time. it is assumed that the load or field conditions are applied gradually.

6. RESULTS

TESTING AND VALIDATION OF VENTED & NON VENTED DISC BRAKE CROSS SECTION

MATERIAL	MODEL	TOTAL DEFORMATION (mm)	EQUIVALENT STRESS (Mpa)	EQUIVALENT STRAIN
GRAY CAST IRON	VENTED	0.0045958	8.9412	8.2068e-5
	NON VENTED	0.051897	17.901	0.0001646
TITANIUM ALLOY	VENTED	0.0054448	8.7275	9.1893e-5
	NON VENTED	0.055934	17.32	0.00018267
STAINLESS STEEL	VENTED	0.002654	8.8766	4.6457e-5
	NON VENTED	0.028952	17.707	9.2832e-5

Tab 1: Comparison results for static structural Ansys



Graph 1: Deformation of different disc brake models

6.1. STATIC ANALYSIS OF DISK BRAKE FOR VENTED MODELS RESULTS AND ANALYSIS OF VENTED DISC BRAKE

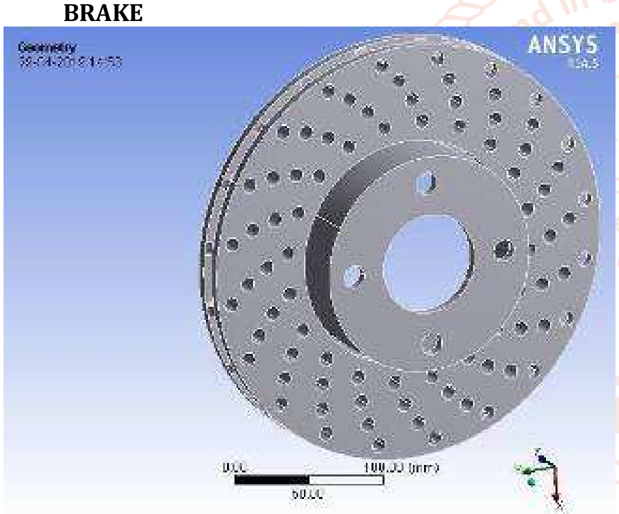


Fig 3: Geometry Diagram

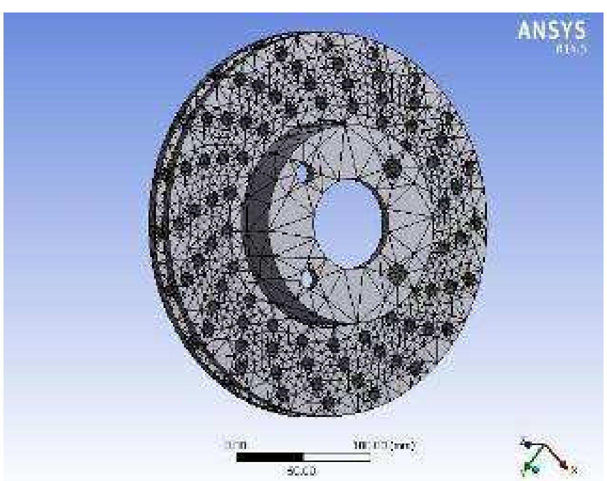


Fig 4: Mesh diagram

1. GRAY CAST IRON

Mass= 8.4311kg, Nodes= 34213, Elements=18347.

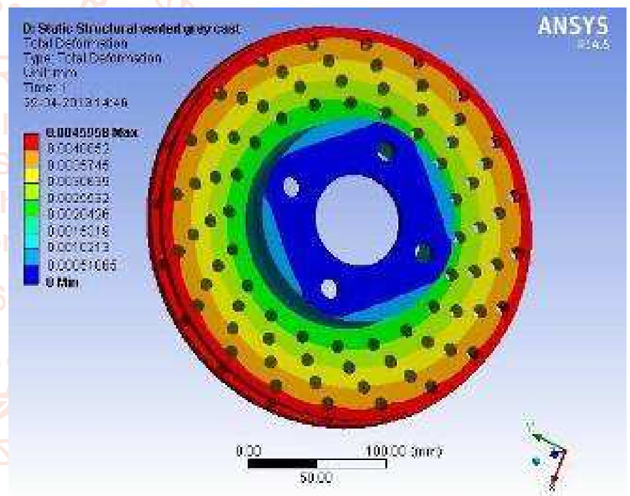


Fig 5: Total deformation

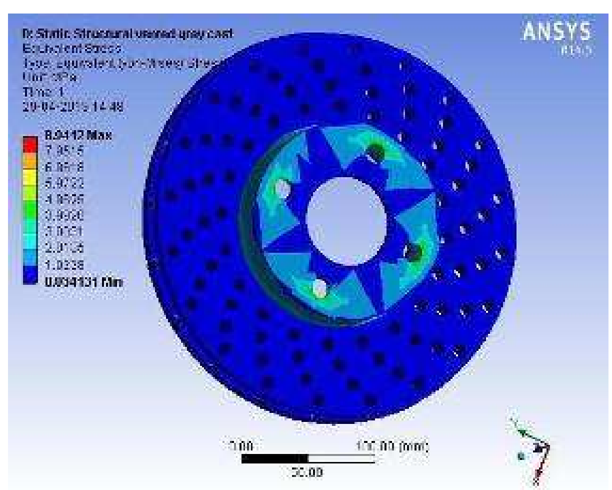


Fig 6: Equivalent stress

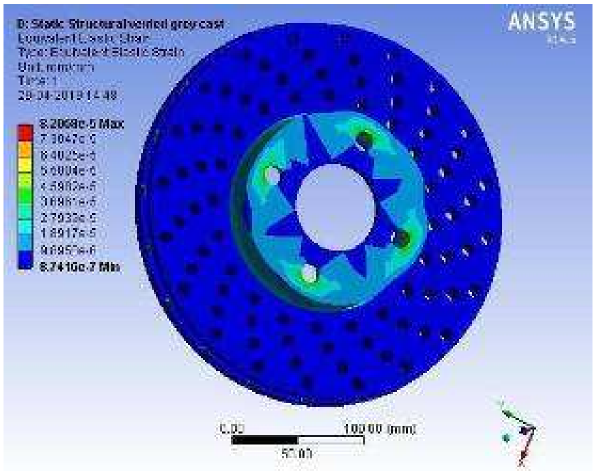


Fig 7: Equivalent Elastic strain

2. TITANIUM ALLOY

Mass= 5.4099 kg, Nodes= 34213, Elements= 18347.

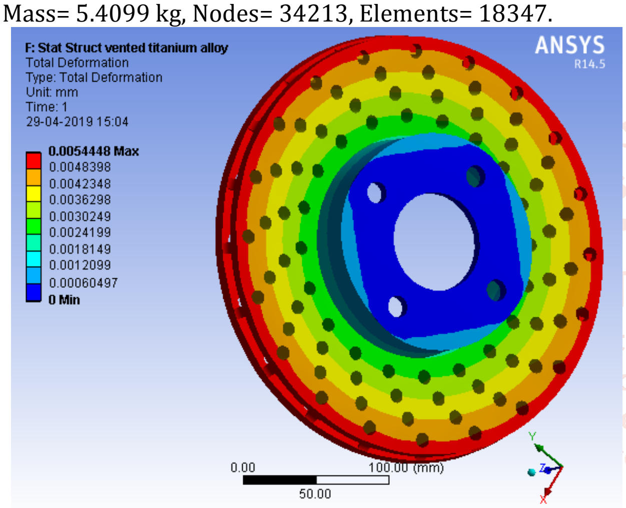


Fig 8: Total deformation

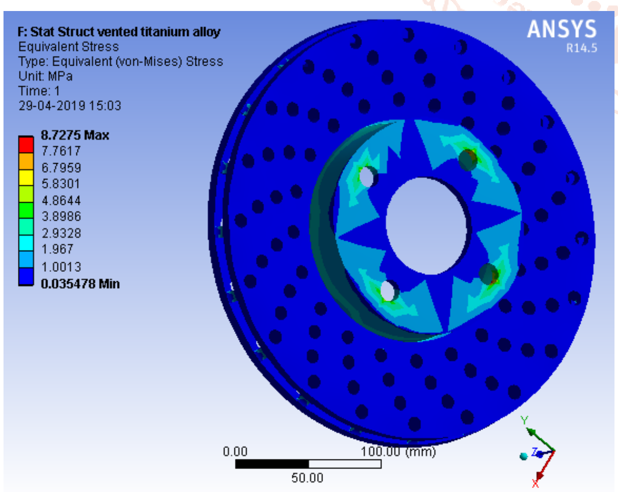


Fig 9: Equivalent stress

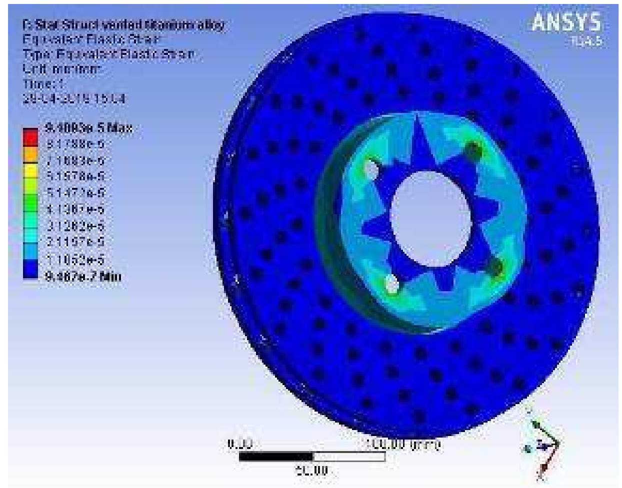


Fig 10: Equivalent Elastic strain

3. STAINLESS STEEL

Mass= 9.0751 kg, Nodes= 34213, Elements= 18347.

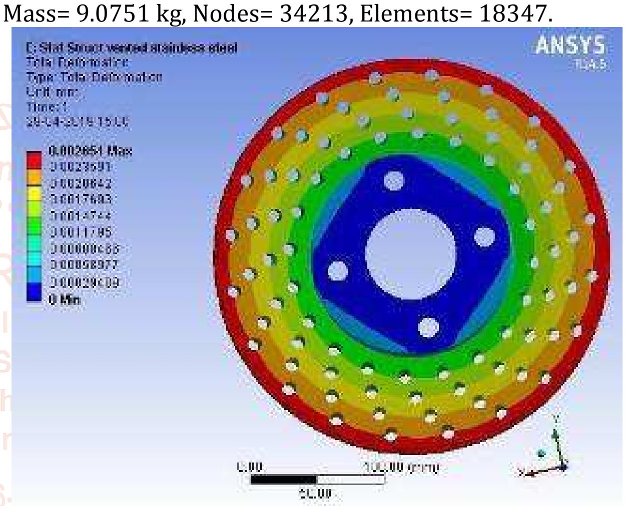


Fig 11: Total deformation

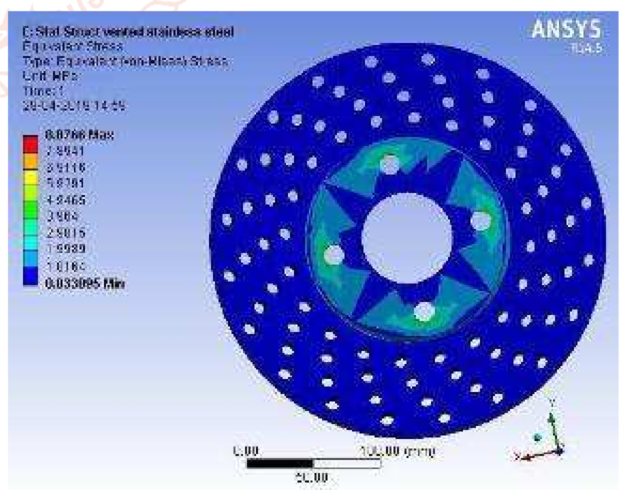


Fig 12: Equivalent stress

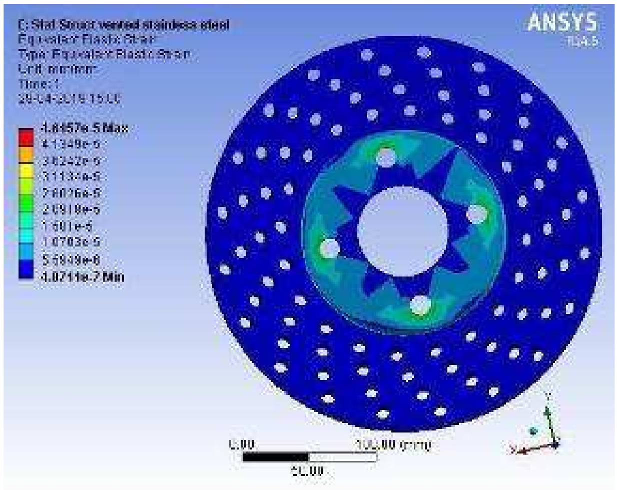


Fig 13: Equivalent Elastic strain

6.2. STATIC ANALYSIS OF DISC BRAKE FOR NON VENTED MODELS RESULTS AND ANALYSIS OF NON VENTED DISC BRAKE

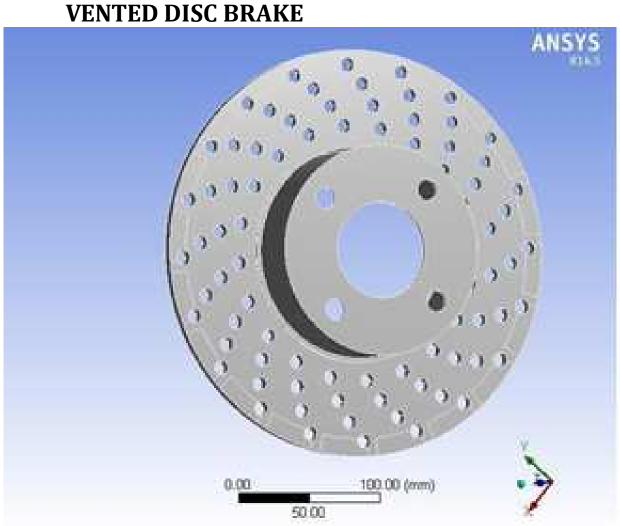


Fig 14: Geometry Diagram

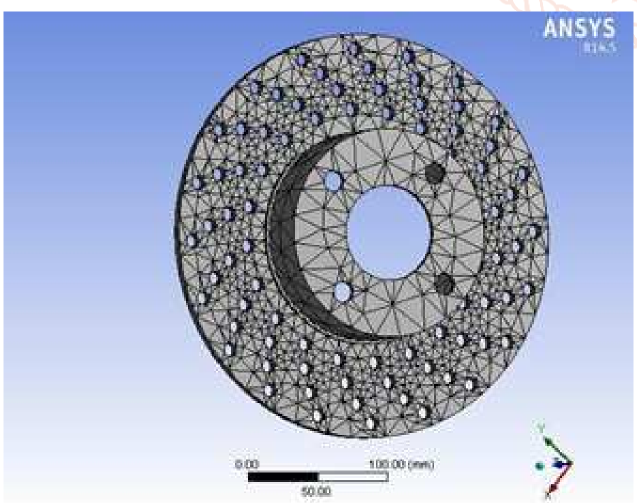


Fig 15: Mesh diagram

1. GRAY CAST IRON

Mass= 3.657kg, Nodes= 16537, Elements= 7967.

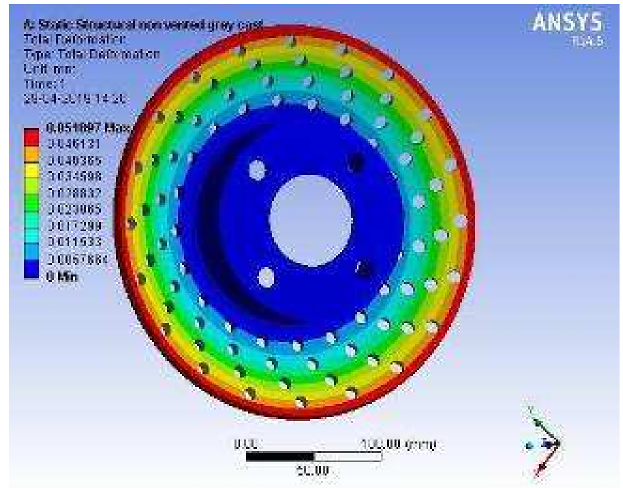


Fig 16: Total deformation

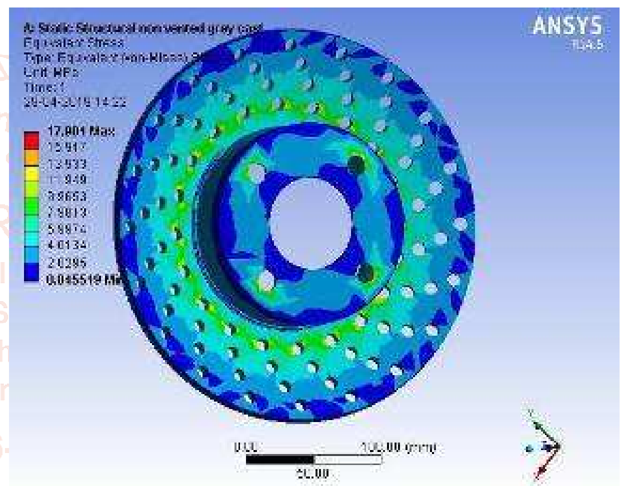


Fig 17: Equivalent stress

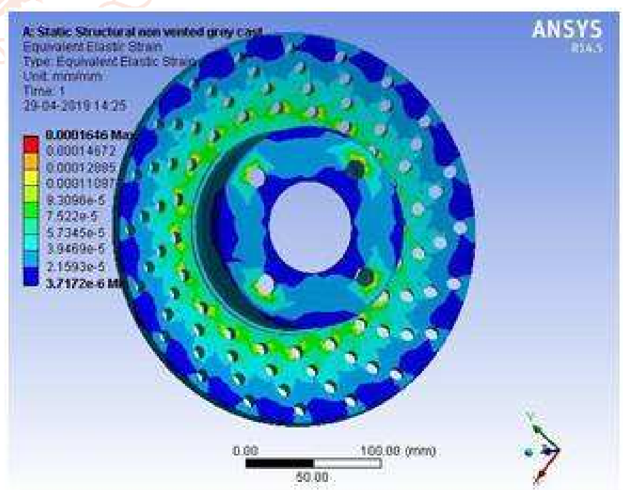


Fig 18: Equivalent Elastic strain

2. TITANIUM ALLOY

Mass= 2.3466kg, Nodes= 16537, Elements= 7967.

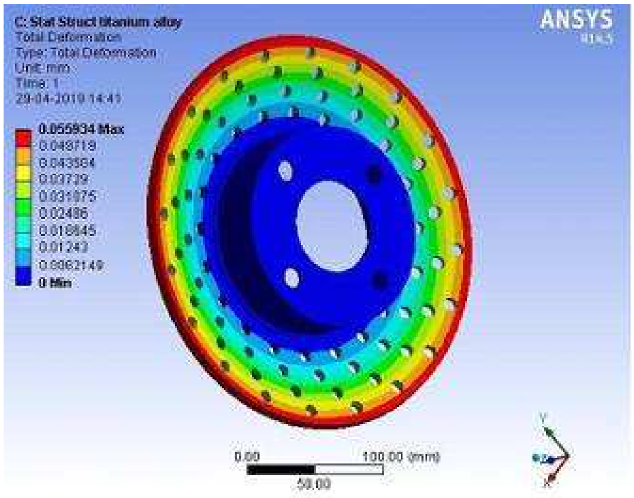


Fig 19: Total deformation

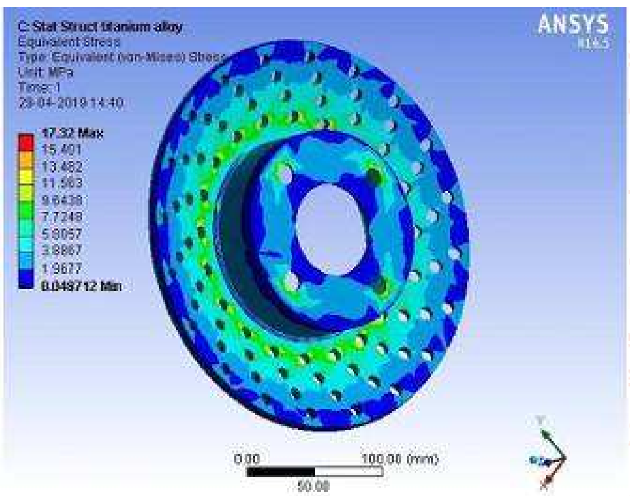


Fig 20: Equivalent stress

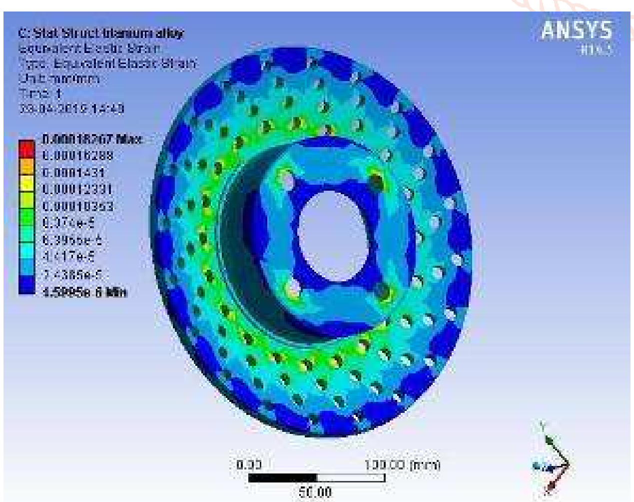


Fig 21: Equivalent Elastic strain

3. STAINLESS STEEL

Mass= 3.9363kg, Nodes= 16537, Elements= 7967.

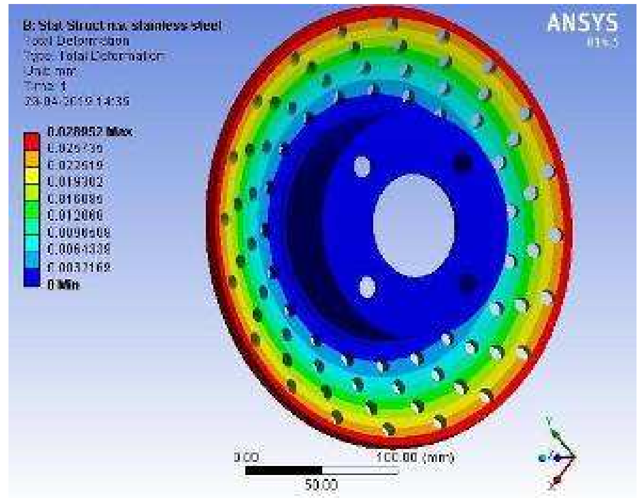


Fig 22: Total deformation

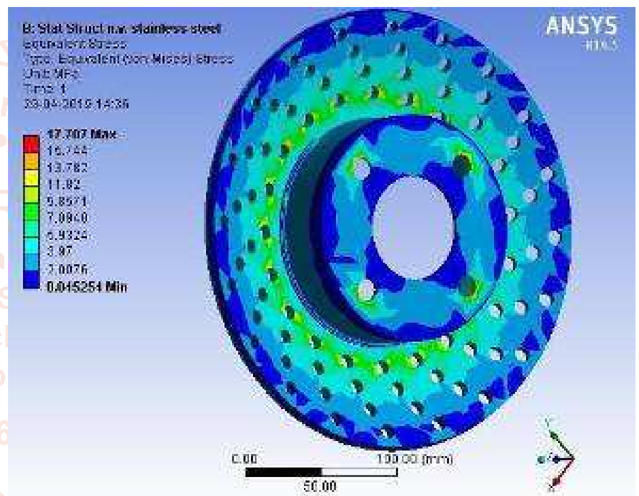


Fig 23: Equivalent stress

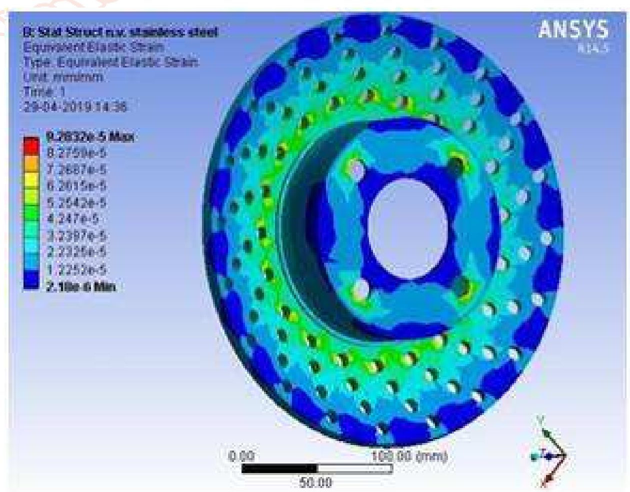


Fig 24: Equivalent Elastic strain

7. CONCLUSION

It is observed that the Vented type disc brakes can provide better Static Structural analysis than the Non Vented disc Brake. It provides useful design tools and improvement of the brake performance in the disk brake system. We can say that from all the values obtained from the analysis i.e. the Total Deformation, Equivalent Stress and Equivalent strain. exhibit that the vented disc is best-suited design. Comparing the different results obtained from the analysis, it is concluded that disk brake with vents and of material Stainless steel is observed best possible combination for the present application.

The finite element results show that the performance of disc brake used in this study of geometry and material properties.

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